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3D assimilation with PIV orthogonal-plane observations and a DNS dynamical model in a circular cylinder wake flow

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ABSTRACT

During the last decade, the fluid mechanics community witnessed the surge of techniques combining computational fluid dynamics and experimental fluid dynamics results in order to benefit from the assets and overcome the limitations of each approach. A first PIV data assimilation study had performed successfully in the two-dimensional case of a DNS of low Reynolds number wake flows [1]. The variational data assimilation technique (4DVar) was used to reconstruct the flow by modifying the initial and inflow conditions of the system. The ability of the technique to reconstruct the flow in gappy PIV data was also investigated [2].

The present study is an extension of the work of [1,2] to the reconstruction of a three-dimensional cylinder wake flow at Reynolds 300 by combining a highly accurate and parallelized code Incompact3d [3] with a sequence of two-dimensional stereo PIV observations. An important part of this application was focused on the construction and validation of the discrete adjoint parallelized code necessary to the implementation of the 4DVar method [4]. We performed a first reconstruction of a purely synthetic flow generated by Incompact3d, using three-dimensional observations. We then performed the reconstruction of a fully three-dimensional flow from the alternated synthetic observations of orthogonal stereo PIV like observations (inflow and streamwise planes see figure 1). We investigate the possibilities of the reconstruction with the real observations obtained by orthogonal stereo PIV measurements.

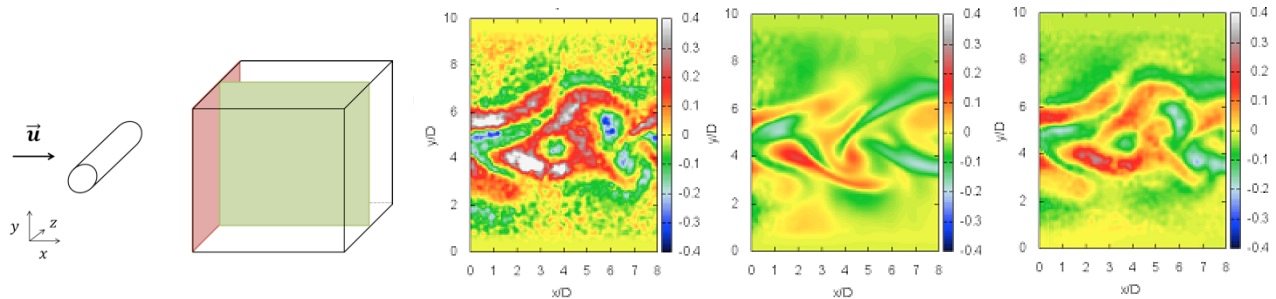


Figure 1 Data assimilation flow configuration ($L_x \cdot L_y \cdot L_z = 8D \cdot 10D \cdot 6D$) and snapshots of the spanwise velocity component at the beginning of the assimilation window in the streamwise plane $z = 3D$. From the left to the right: the PIV observation, the background and the analysis, respectively.

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